Exporting and Productivity: The Importance of Reallocation

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First version, April 1999 This version, April, 2001 v6.0

Abstract

Exporting is often touted as a way to increase economic growth. This paper examines whether exporting has played any role in increasing productivity growth in U.S. manufacturing. While exporting plants have substantially higher productivity levels, there is no evidence that exporting increases plant productivity growth rates. However, within the same industry, exporters do grow faster than non-exporters in terms of both shipments and employment. Exporting is associated with the reallocation of resources from less efficient to more efficient plants. In the aggregate, these reallocation effects are quite large, making up over 40% of total factor productivity growth in the manufacturing sector. Half of this reallocation to more productive plants occurs within industries and the direction of the reallocation is towards exporting plants. The positive contribution of exporters also shows up in import-competing industries and non-tradable sectors.

KEY WORDS: export-led growth, total factor productivity, productivity growth, reallocation, international trade

JEL Classification: F10, F43, O47

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We are grateful to seminar participants at the NBER, Dartmouth, Harvard, NYU, Toronto, Yale, the IMF, the World Bank, and the EIIT conference for helpful comments. The research in this paper was conducted at the Center for Economic Studies. Research results and conclusions expressed are those of the authors and do not necessarily indicate concurrence by the Bureau of the Census. The paper has not undergone the review the Census Bureau gives its official publications. It has been screened to insure that no confidential data are revealed.

1 Introduction

Recent years have seen a resurgence in interest in the role of international openness and international trade in economic growth. While the role of trade in promoting economic well-being has a long tradition in the trade literature, the interaction between international trade and long run output and productivity movements is less well understood. In this paper, we explore whether international trade increases productivity growth within economic units or whether there are productivty effects at a more aggregate level as a result of the reallocation of resources across plants or industries. We provide direct evidence based on microeconomic data of how trade might be related to aggregate total factor productivity growth rates.

Our research focuses on the role of exporting in increasing productivity growth in U.S. manufacturing. We concentrate on the hypothesis that exporting has a causal impact on growth rates of productivity. By using microeconomic data at the plant level, we look for evidence that participation in the export market leads to faster productivity growth.

The relationship between exporting and productivity has important implications for several current areas of research. The debate on the role of international openness in facilitating economic growth has been conducted almost exclusively with aggregate cross-country data. Several recent studies, including Ben-David (1993) and Sachs and Warner (1995), have provided empirical evidence that trade and growth are positively related. Ben-David (1993) shows that members of the EEC had faster output growth rates as trade increased following the removal of trade barriers.[1] Sachs and Warner (1995) conclude that a substantial fraction of the differences in cross-country growth rates over a 30 year period can be correlated with a measure of openness to trade. Marin (1992) finds that an outward-oriented regime is associated with productivity growth in industrialized countries. A recent collection of research on openness and growth, Proudman and Redding (1998), conducts both cross-country and cross-industry analyses and strongly concludes that trade facilitates productivity growth. In all this work, the exact mechanism by which openness affects growth is not revealed. In this paper, we will look at the some of the underlying activity induced by increasing trade. We test whether international trade increases productivity growth within economic units or whether there are any productivity effects at a more aggregate level due to the reallocation of resources across plants or

[1] See Slaughter (2001) for a discussion of the caveats in interpreting these results as causal.

industries.

This paper is a natural extension of the recent work on the microeconomics of trade and exporting. There is substantial accumulated evidence that the act of exporting occurs in firms with very different observable characteristics, even within the same industry.[2] Exporting plants have higher productivity and shipments levels and are more technologically sophisticated than other plants in the same industry (Bernard and Jensen 1995). However, recent work has suggested that exporting confers little or no benefit in the form of faster productivity growth at the plant level (Clerides, Lach, and Tybout 1998, Bernard and Jensen 1999). We extend that work by considering not just the within-plant effects of exporting, but the importance of cross-plant and cross-industry reallocations.

Using plant data, we find little evidence that exporting increases productivity growth rates relative to domestic activity. However, again within the same industry, exporters do grow faster in terms of both domestic and foreign shipments than non-exporters. We confirm that, both within and across industries, exporting is associated with the reallocation of inputs, both labor and capital, from less efficient to more efficient plants. These effects are not predominantly associated with the changing fortunes of different industries. Fully half of this reallocation occurs within industries.

We recognize that our exclusive focus on exports leaves the import part of the trade and productivity relationship unexplored. This is largely because we are constrained by the data; the micro data at the plant and firm level contains no information on imported inputs. The importance of omitting imports is hard to judge. We know from the literature on intra-industry trade that imports and exports tend to move together at the industry level. To the extent that imports and exports have similar effects on productivity, we may mistakenly confound the impact of exports and imports. We avoid this problem in part by working from the plant level to the industry in determining the relationship between exporting and productivity.

The paper proceeds as follows: first we present the micro evidence on the productivity-exporting nexus and results on the growth of exporters and non-exporters. In Section 3, we decompose changes in aggregate productivity in manufacturing into components due to within plant productivity increases and the reallocation of resources across plants and industries. Section 4 concludes.

[2] For evidence from other countries, see Bernard and Wagner (1997) on German plants and Aw and Hwang (1995) for Taiwanese firms.

2 Trade and Productivity

We begin by outlining several mechanisms by which trade might affect productivity levels. We recognize the possibility that faster productivity growth allows firms, industries, and the economy to increase the flow of exports. Roberts and Tybout (1997) develop a model of exporting with sunk costs of entry and test it on a sample of Colombian firms.[3] In the presence of these entry costs, only the relatively productive firms will choose to pay the costs and enter the foreign market. The implied relationship between exporting and productivity is positive in a cross-section of firms or industries, but the causality runs from productivity to exporting. Substantial sunk costs of export entry are not limited to developing countries. Bernard and Jensen (1997) find significant sunk costs for U.S. plants and Bernard and Wagner (2001) get similar results for firms in Germany, a relatively open, developed economy.

Traditional, static trade models yield predictions about the role of trade in improving productivity. For example, a simple one factor Ricardian model with specialization after opening to trade yields increased welfare for all countries. By assumption there is no role for within-industry productivity increases, but relative price changes increase the real output produced in each country and labor moves towards the industry with comparatively high labor productivity.

Two recent papers, Bernard, Eaton, Jensen and Kortum (2000) and Melitz (2000) emphasize the importance of trade-driven reallocation effects in aggregate productivity. Bernard et al. (2000) develop a Ricardian model of heterogenous plants and trade. For individual plants, ex-ante productivity differences determine whether the plant exports or not; exporting does not drive productivity. However, reductions in trade barriers or other increases in openness will increase aggregate productivity as more productive plants grow and the least productive plants fail. Melitz (2000) develops a dynamic industry model with heterogeneous firms where trade causes reallocations of resources among firms in an industry. Only the most productive firms enter the export market and while the least productive firms stop producing altogether. Increases in the industry's exposure to trade lead to additional inter-firm reallocations towards more productive firms. Throughout the rest of this paper, we look for both within-industry, and within-firm, effects of trade, as well as reallocative effects due to shifting composition of

[3] Clerides, Lach, and Tybout (1998) also find evidence of sunk costs in Morroco and Mexico.

firms within industries, or industries within manufacturing.

2.1 Data Sources

The data used in this paper come from the Annual Survey of Manufactures (ASM) from the Longitudinal Research Database (LRD) of the Bureau of the Census. Since we are interested in behavior before and after exporting, we choose our sample to contain the longest currently available period of continuous coverage on exports, 1983-1992. For comparisons involving more than one year we are limited to plants included in the ASM.[4] This results in an unbalanced panel with 50-60,000 plants in each year. Due to missing data on capital stocks from 1988-1991 we are forced to construct our own capital stock series from the reported investment series. Appendix A contains a detailed description of the capital stock data.

2.2 Exporting, growth and productivity at plants

To develop our understanding of the relationship between exporting and productivity, we look at data on individual plants in the manufacturing sector. Exporting plants have desirable performance characteristics relative to non-exporters, especially labor productivity. Bernard and Jensen (1999) report plant labor productivity differentials 16%-19% higher for exporters in the same 4-digit industry. They also report TFP differentials of 13%-16%, assuming a common production function within the four digit industry with time-varying coefficients. In this paper, since we are interested in the role of exporting in aggregate productivity growth, we estimate all our specifications with plant-level observations weighted by their sampling probabilities in the LRD. Throughout the paper, our productivity measures are derived from plant-level estimates of multi-factor productivity.[5] Appendix B contains the detail on the construction of the productivity measure.

If trade improves productivity at individual firms, we would expect firms involved in international trade to have faster productivity growth than firms

[4] The design of the ASM imposes some structure on our analysis. Some plants are included with certainty in each ASM 5 year wave. These 'certainty' cases include all plants with more than 250 employees. Other, generally smaller plants, are included with some probability (<1) in each wave. However, if a non-certainty plant is included in one 5-year wave it will not be included in the next. See Census (1987) for more information. All industries are classified on a 1972 SIC basis.

[5] None of our results depend on the specific form of the productivity measure. Labor productivity and alternative total factor productivity measures yield similar results.

engaged only in production for the domestic market. We look at the relationship between the export status of a plant today and subsequent productivity performance in Table 1. Regressions are of the form

$$\Delta \ln \text{Productivity}_{it+1} = \alpha + \beta \text{Exporter}_{it} + \gamma Z_{it} + \varepsilon_{it}. \tag{1}$$

The set of additional controls, Z_{it}, varies across specifications. Column 1 adds no controls, i.e. just compares mean productivity growth rates at exporters and non-exporters. Column 2 includes year dummies, while columns 3 and 4 adds 2-digit (SIC) and 4-digit industry dummies respectively, i.e. we are comparing the productivity growth rates within industries in the same year. Each observation is weighted by its sampling probability in the ASM to generate the universe of manufacturing plants in the U.S..

We find no evidence that the export status of a plant this year is significantly positively correlated with one year ahead productivity growth. For all specifications, we actually obtain negative coefficients; exporters today have productivity growth rates 0.72% per year lower than similar plants producing solely for the domestic market.

One possible explanation for the sub-par productivity performance of exporters is that we are mixing firms that continue exporting, so-called export successes, with those that stop, export failures. Similarly non-exporters today may enter or remain out of the market. To address these issues, we rerun our regressions with three export status dummy variables, one for exporters throughout, i.e. in both periods [1,1], one for firms that leave the export market , stoppers [1,0], and one for new exporters, [0,1].[6] The base group is the set of firms that export in neither year. The results, presented in Table 2, do indicate that the four groups have very different productivity trajectories. In particular, in the year that they enter the export market, starters have significantly faster productivity growth rates than other firms. The magnitudes of the total factor productivity growth rate differences for starters are relatively large, ranging from 1.2% to 2.5% higher than plants that do not export in either year. Similarly, plants that exit the export market have productivity growth rates 0.2%-0.9% lower than continuing non-exporters.

The results for continuing exporters depend on the specification. Unconditionally, exporters have TFP growth rates that are exactly the same as non-exporters. In part this is because exporting industries have higher

[6] We caution that by constructing our variables in such a fashion, we are using ex-post information on the RHS of the regression. No conclusions about directions of causality are warranted.

TFP growth rates overall. Within industries, we again find that continuing exporters underperform non-exporters in terms of productivity growth.

The results in this section speak directly to the question of whether an export presence improves subsequent productivity performance at the micro level. Unconditionally, exporters fare no better, and often worse, than non-exporting plants. This is in large part because of the good productivity performance of entrants and the poor performance of exiting plants. Continuing exporters and continuing non-exporters in the same industry have virtually identical productivity trajectories. If exporting has a role in improving industry productivity growth it must come through some other channel than improving within plant outcomes.

2.3 Productivity Before and After Entry (and Exit)

In this section, we consider the relationship between productivity paths and exporting in greater detail. The previous results show that productivity growth is higher at entrants, lower at exits and slightly worse for continuing exporters than at continuing non-exporters. This still leaves open the question of what exactly is going on in plants that are entering and exiting the export market. To shed light on these changes, we run a regression of the form

$$\ln PR_{ijt} = c_{jt} + \sum_{e \in E} \sum_{x \in X} d_i^e \cdot d_{ijt}^x + \varepsilon_{ijt} \tag{2}$$

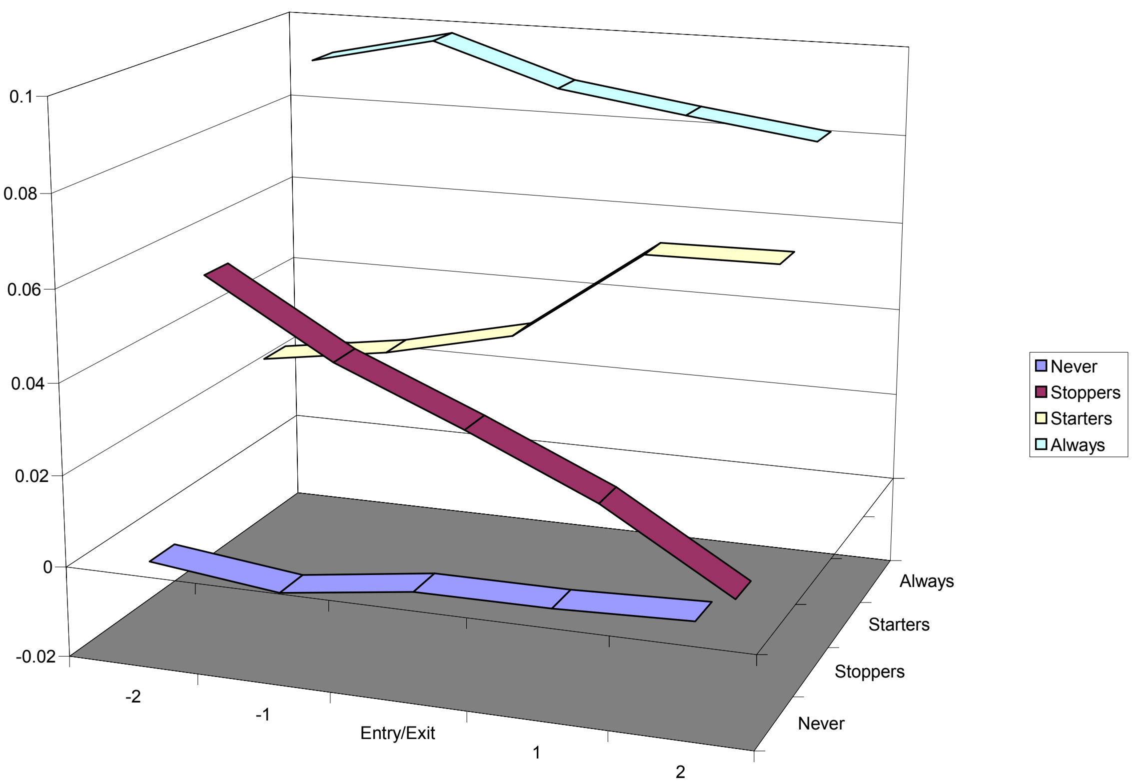
where $\ln PR_{ijt}$ is the log level of the plant productivity measure, d_i^e is an indicator variable for the export firm type and d_{ijt}^x is an indicator variable for the export status of firm that year. We allow 5 firm export types, d_i^e, which are:

- Always - exports in all years
- Starter - becomes an exporter during the period (and does not reswitch)
- Other - switches export status more than once[7]
- Stopper - ceases exporting during the period (and does not reswitch)
- Never - does not export in any year.

We consider five year intervals and thus are able to track firms from two years before entry (or exit), i.e. $d_{ijt}^x = -2$, through entry (or exit), i.e.

[7] This group is suppressed in the figures.

Figure 1: Paths of TFP (purged of industry and year effects)



$d^x_{ijt} = 0$, to two years after entry (or exit), $d^x_{ijt} = 2$. The interaction of the indicator variables will give us a picture of the relative productivity levels of all five types of firms as they move in and out of exporting.

Figure 1 shows the results for TFP for the different types of firms (omitting the "other" category from the pictures but not the tables); Table 3 contains the coefficients and standard errors. Due to the structure of the regressions, the figure and the table show us the productivity paths of plants net of any aggregate industry productivity increases. With this specification we can track the productivity path for plants for several years before and after they start exporting (or stop).

The differences in productivity levels between the types of plants are large, significant, and in the expected directions. Plants that always export are 8%-9% more productive than plants that never export. This confirms evidence from previous studies about the relative productivity of exporters and non-exporters. The relative positive of continuing non-exporters and continuing exporters also does not change over time, confirming the results from the previous section that exporting is not changing the productivity paths of these plants

The results for entering and exiting plants are of particular interest. New entrants into exporting have productivity levels significantly above continuing non-exporters but significantly below continuing exporters fully two years before they start exporting. These plants are relatively good before they enter the export market, improve through their first year of exporting, and then resemble the pool of continuing exporters. By the end of the five year window their productivity levels are not significantly below those of plants that exported throughout. Exits from exporting show comparable deterioration of their productivity levels. Several years prior to exit, these future export failures start at levels typically worse than their exporting counterparts and above non-exporters. But by the end of the period their productivity levels have fallen to those of plants that did not export at all.

These results offer two perspectives on the interaction between exporting and plant productivity. Times of transition, either in or out, are indeed associated with large productivity changes. However, these changes predate the start (or end) of exporting and are completed soon after entry (exit). In contrast, continuing exporting does not result in faster productivity growth rates.

2.4 Plant Growth - Shipments and Employment

One mechanism by which exporters may contribute to productivity gains in the industry or in the aggregate is through a combination of higher productivity levels and faster overall growth. The evidence presented above suggests that high productivity firms enter the export market, rather than exporting leading to high productivity. However, if these high productivity exporters also grow faster, in terms of employment and output, we would expect to see rising industry productivity levels as more firms enter the export market. This kick to industry productivity is not permanent; both before any entry takes place and after all firms have started exporting, the industry growth rate would be completely determined by non-export factors.

In this section we estimate the relationship between overall plant growth, both shipments and employment, and initial export status. We again estimate a regression of the form,

$$\Delta \ln \text{Size}_{it+1} = \alpha + \beta \text{Exporter}_{it} + \gamma Z_{it} + \varepsilon_{it}, \tag{3}$$

with similar sets of controls.

The results for employment, total value of shipments, and domestic shipments are given in Table 4. Unlike productivity growth rates, all measures of firm growth are strongly positively correlated with initial export status. Employment growth is 0.79%-1.08% per year faster at exporters than non-exporters. Results for growth in the total value of shipments range from 0.57%-1.32%. The results for domestic shipments are even more dramatic. Exporters expand their domestic shipments between 3%-4% faster than non-exporters.

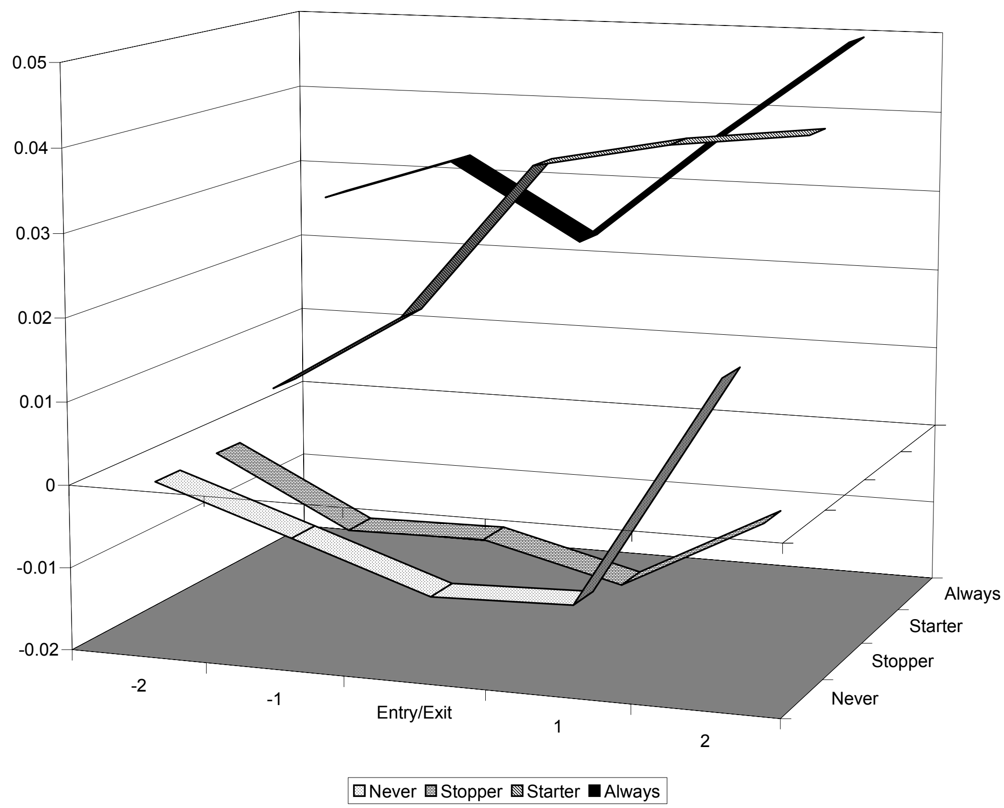
2.5 Employment Growth Before and After Entry (and Exit)

These results show that employment growth is high for both future exporters and ongoing exporters. Again this leaves open the question of what exactly is going on in plants that are entering and exiting the export market. We rerun the specification in Equation 2 with employment growth rates as the dependent variable.

Figure 2 shows the results for employment growth for the different types of firms; Table 5 contains the coefficients and standard errors. The differences between the types of plants are significant and in the expected directions. Plants that always export have employment growth rates 2%-4% higher than plants that never export. New entrants into exporting start with higher employment growth rates than non-exporters, but lower than continuing exporters. These entrants see continued increases in their employment growth rates after they become exporters.

While exporting does not appear to improve productivity growth rates at the plant level, it is strongly correlated with increases in plant size. Both employment and shipments growth are significantly faster at exporters. In particular, these exporting plants increase their domestic shipments substantially faster than non-exporters. Combined with previous work on the productivity advantages in levels for exporters, these results suggest that the reallocation of resources across plants, both within and across industries, may be an important mechanism for trade to affect productivity growth. In the next section we attempt to quantify the aggregate impact of the rapid expansion of exporting plants.

Figure 2: Paths of Employment Growth Rates (purged of industry and year effects)



3 Reallocation of resources within and across industries

The results from the previous section suggest that expansion of international trade, and exports in particular, may have effects predicted by the heterogenous firm models of Bernard et al (2000) and Melitz (2000). Trade enables efficient producers within an industry, and efficient industries within the economy, to expand. As these relatively productive units grow, overall productivity levels rise. The lack of within plant productivity effects indicates that the potential for higher long run productivity growth rates is limited. In light of the evidence presented above, we decompose changes in industry and overall manufacturing productivity growth rates into within-plant and between-plant effects. Given our previous results, we expect to find significant between-plant effects for exporting plants. Some fraction of aggregate productivity growth will be due to the increased scope of activity at high-productivity, exporting establishments.

3.1 Decomposing aggregate productivity growth

The results on plant level productivity changes suggest that continuous exporting plants do not have significantly higher productivity growth rates than continuous non-exporting plants but that employment and shipments do grow faster at exporters. In this section, we attempt to quantify the importance of the increasing export orientation of U.S. manufacturing on overall manufacturing total factor productivity growth.

We can decompose the annual change in aggregate total factor productivity into within plant (Own) and between-plant (Reallocation) effects,[8]

$$\Delta PR_A = \sum_{i=1}^{I} \Delta \left(PR_i \cdot SH_i \right) = \underbrace{\sum_{i=1}^{I} \Delta SH_i \cdot \overline{PR_i}}_{\text{Reallocation Effect}} + \underbrace{\sum_{i=1}^{I} \Delta PR_i \cdot \overline{SH}_i}_{\text{Own Effect}} \qquad (4)$$

where PR_i is the productivity at an individual plant and SH_i is the share of total output at the plant.

The *reallocation* effect is the product of the change in the output share from year $t-1$ to year t at the plant, ΔSH_i, and the average total factor

[8] For our decomposition analysis, we work only with continuing plants, i.e. plants that exist in years t and $t+1$. The exclusion of plant failures and plant births does not have a significant effect on our results.

productivity in year $t-1$ and t, $\overline{PR_i}$. The *own* productivity effect is the product of the average output share and the change in the plant TFP.[9]

This decomposition, while not unique, allows us to quantify the degree to which aggregate productivity growth is driven by more productive plants growing larger or plants becoming more productive. A positive *reallocation* effect results from an increasing share of total output at plants with higher than average productivity. The *own* effect is positive if the mean of output weighted within-plant productivity growth is positive. This component will be dominated by plants with relatively large productivity changes in levels and/or large plants with positive productivity growth. Of course, if the high productivity plants have the highest productivity growth rates then the *own* effect will be large.

An advantage of the decomposition presented above is that we can group plants into categories, i.e. by four-digit industries or export status of the plant. We transform the decomposition given above into one for aggregate productivity growth rates,

$$\Delta PR_A = \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta SH_i\cdot\overline{PR_i}}_{\text{Reallocation Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i\cdot\overline{SH}_i}_{\text{Own Effect}}$$

where j represents the group for plant i. We choose to cluster plants into four groups based on their export status in the two years (starter, throughout, stopper, and neither). We then can compute the fraction of overall growth due to growth of plants in each category and due to within-plant productivity growth in each category.

In Table 6, we decompose annual average aggregate TFP growth for continuing plants in the manufacturing sector.[10] Overall TFP at continuing manufacturing plants grew at average annual rate of 1.42% from 1983 to 1992. While the dominant source of aggregate productivity growth was the own-productivity effect, accounting for 58% of the total, changes in output shares among plants were surprisingly important in overall growth. 42% of aggregate TFP growth came about because of increasing output shares at more productive plants. These estimates suggest important roles for the

[9] We calculate the components year by year for each plant and then average across all the years in the sample.

[10] The computer industry (SICs 3571, 3572, 3575, and 3577) represents a problem in the 1972 SIC classification due to difficulties with the output deflator. Our general conclusions are not sensitive to the inclusion of these sectors.

reallocation of resources towards more productive plants.[11]

Our results so far have suggested that continuing exporters grew substantially faster in terms of employment and output and thus should account for the preponderance of any reallocation effects. The decomposition results confirm this hypothesis as over 87% of overall TFP growth comes from the expansion of continuing exporters. The net effect of entrant and exits from exporting is slightly positive in terms of the change in output shares while continuing non-exporters show negative reallocation components due to their slower than average output growth. Put in other terms, had there been no changes in relative output shares across plants, TFP growth in the manufacturing sector would have been 0.82% instead of 1.42% per year.

Turning to the own productivity components, we find once again that continuing exporting plants are by far the most important group, with own productivity effects more than four times as large as continuing non-exporters. This may seem surprising after the plant level results which showed no relative productivity growth advantage for exporters (or even continuing exporters). However, plants with high initial productivity levels contribute more to aggregate productivity growth than plants with low productivity levels, even if they have the same growth rates. Exporters are substantially more productive than non-exporters in the same industry, and they are more likely to be located in high productivity industries. This combination of level effects leads exporters to contribute disproportionately to aggregate growth.

One question is whether these reallocation effects are occurring within or across industries. Most trade theories use the industry as the unit of analysis and hypothesize gains from cross-industry changes. The decomposition above argues that cross-plant magnitudes are substantial. An industry-level decomposition reported in Table 7 shows that just under half of the reallocative activity (22.5%) occurred within 4-digit industries and half occurred because of changing output shares across industries (19.4%). The big impact on manufacturing productivity of fast growth at exporting plants is as much a within-industry phenomenon as it is one of the relative rise and fall of different sectors.

These decompositions overstate the role of trade in the reallocation of resources and overall total factor productivity growth. We know that domestic shipments also grow more quickly at exporting plants, and that ex-

[11] Baily, Hulten and Campbell (1992) estimate reallocation effects of 31% for the period 1972-1987 using similar methods. Aw, Chen, and Roberts (1997) find that within-firm productivity growth and firm entry and exit play large roles in productivity growth in Taiwan and reallocation across plants plays only a minor role.

ports typically make up only a small fraction of plant output[12]. To provide a better estimate of the relative importance of domestic and foreign shipments we further break out reallocation and own-productivity effects into domestic and foreign components. The decomposition is given by

$$
\begin{aligned}
\Delta PR_A \;=\; & \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta DSH_i\cdot\overline{PR_i}}_{\text{Domestic Reallocation Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta FSH_i\cdot\overline{PR_i}}_{\text{Foreign Reallocation Effect}} \\
& + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i\cdot\overline{DSH_i}}_{\text{Domestic Own Effect}} + \underbrace{\sum_{j=1}^{J}\sum_{i\in j}\Delta PR_i\cdot\overline{FSH_i}}_{\text{Foreign Own Effect}}
\end{aligned}
$$

where DSH_i is the ratio of domestic shipments by the plant to total manufacturing output and FSH_i is the ratio of exports by the plant to total manufacturing output. We assume for this analysis that productivity levels are the same within plants for both types of shipments. The results are presented in Table 8.

As expected, continuing exporters show positive reallocation contributions for both domestic and foreign shipments. This confirms that these plants are in general growing faster. However, the increases in foreign shipments at these plants are the main source of reallocative activity. Fully 70% of the reallocation effect at continuing exporters is due to export growth. In contrast, exports contribute relatively little to the own-productivity effects (12%). This is because exports, while growing rapidly, remain a relatively small share of total shipments at exporting plants.

Since these decompositions are not unique, we cannot use them to precisely quantify the importance of exporting to aggregate productivity growth. However, in an effort to provide a sense of the importance of these effects, we focus on two numbers which most likely bound the importance of the role of exporting to TFP growth. The first comes from the results reported in Table 8. Summing the reallocative effects and own-productivity effects for continuing exporters attributed to foreign shipments, we find an upper bound of 65% of aggregate TFP growth. We caution that this is probably a large overstatement of the importance of exporting in aggregate manufacturing.

To calculate a lower bound, we assume that the paths for productivity and domestic shipments for plants would not change if they had no access to

[12] See Bernard and Jensen (1995).

the foreign market. We then reestimate our decomposition in Table 7, eliminating exports from total shipments and recalculating plant output shares. This increases the importance of non-exporters, but also assumes that in the absence of a foreign market, the more productive exporting plants could not further increase their domestic market share. The new counterfactual decomposition is given in Table 9. As expected the bulk of the change in aggregate productivity is concentrated mostly in the reallocative effect which falls 15%. Aggregate TFP growth under these assumptions falls by 7.8% which represents our lower bound for the importance of exporting to aggregate TFP growth.

3.2 Exporting and Importing Industries

Finally we return to the role of imports in aggregate productivity growth. As mentioned earlier we have no information on imported intermediate inputs at the plant level. We instead use information on imports and exports at the 4-digit industry level. We divide industries into five categories based on their export and import intensity at the beginning of the sample and calculate the reallocation and own-productivity effects[13].

- Trade intensive - top quartile in both export and import intensity [7% of industries, 5.0% of employment]
- Export intensive - top quartile in export intensity but not in import intensity [18% of industries, 24.5% of employment]
- Import intensive - top quartile in export intensity but not in import intensity [18% of industries, 12.4% of employment]
- Non–tradeable - bottom quartile in both export and import intensity [12% of industries, 14.7% of employment]
- Other - remaining industries [45% of industries, 43.4% of employment]

Table 10 reports the reallocation and own-productivity effects for the five industry types while Table 11 reports the contributions of different plant types within industries. As expected from the earlier decompositions, both types of export-intensive industries show large positive reallocative effects. In contrast, import competing and non-tradable industries are growing more slowly and have large negative reallocative contributions. Interestingly the

[13] Relative trade intensities are largely unchanged across the sample.

non-tradable sector also has declining plant level productivity growth over the sample leading to a negative own-productivity contribution.

Given the importance of exporting in reallocation, the results from Table 10 are perhaps not that surprising. However, when we look within sectors in Table 11, we once again find a dominant role for exporting plants, even in the import-competing and non-tradable industries. Starters and continuing exporters dominate both the reallocative and the own-productivity contributions to aggregate productivity growth in all industries types. While we emphasize that productivity growth at these plants is not enhanced by exporting the faster shipments growth leads to a disproportionate contribution to aggregate TFP growth even in 'non-export' sectors.

4 Conclusions

The interplay between productivity and international trade has implications for a wide variety of fields in economics from the cross-country study of long run growth to the evolution of inequality within countries. In this paper, we have explored the relationship between productivity and exporting in the U.S. manufacturing sector. Building on previous research, we have found no evidence that exporting per se is associated with faster productivity growth rates at individual plants. The positive correlation between exporting and productivity levels appears to come from the fact that high productivity plants are more likely to enter foreign markets. The productivity path for a plant switching from non-exporter to exporter shows a rise in productivity levels before and during entry, and a flat trajectory thereafter.

High productivity before entry is not the end of the story. Our results show that employment and output growth rates are much higher at exporters and employment growth continues to increase after entry. This faster growth of exporting plants, coupled with their higher productivity levels, provides an alternative, reallocative mechanism for exporting to augment aggregate productivity growth.

The magnitudes of these shifts of employment towards high productivity exporters are quite large. From 1983-1992, more than 40% of total factor productivity growth in the manufacturing sector resulted from changing output shares across plants. Almost all of these reallocative effects resulted because high productivity exporters grew faster than lower productivity non-exporters. Exporters account for 46% of total employment in our sample but contribute a far greater percentage to aggregate TFP growth. Even in non-tradable and import-competing sectors, exporters grow faster and contribute substantially to aggregate productivity growth.

Trade improves welfare by facilitating the growth of high productivity plants, not by increasing productivity growth at those plants. The results contain both good news and bad news for long run growth rates. Increased trade will contribute to aggregate productivity growth, but the effect is one of increased levels, rather than an increase in the long-run growth rate itself. However, the magnitude of these 'one-time' level changes are large and, given the relatively low export shares for U.S. industries, are far from being exhausted.

The results presented here suggest that the within-industry effects of trade may be as, or more, important than the cross-industry effects. Much work remains to be completed to develop our understanding of the impact of international trade on productivity growth, especially concerning the role of imports on productivity and employment. Of particular interest is an examination of the role of international trade as a force for efficient reallocation of resources in countries away from the technology and productivity frontier.

A Plant Capital Stocks

Unfortunately the data on plant level capital stocks were not collected for the years 1988-1991. To construct plant measures of TFP we must construct proxies for plant capital from initial or ending year capital stocks and the data on investment in the intervening years using a perpetual inventory method. Since we do not directly observe depreciation we calculate an average depreciation from the years for which we have full information on capital stocks and investment. Every plant in our sample appears in either the 1987 or 1992 Census of Manufactures or both. We construct separate estimated capital stocks from each endpoint and for plants in the sample in both 1987 and 1992 we use the average of the estimates.

$$
\begin{aligned}
\overrightarrow{K}_{i,1987+m} &= (1-\delta)^m \cdot K_{i,1987} + \sum_{s=1}^{m} (1-\delta)^{s-1} \cdot INV_{i,1987+s} \\
\overleftarrow{K}_{i,1992-j} &= \left(\frac{1}{1-\delta}\right)^j \cdot K_{i,1992} - \sum_{s=1}^{j} \left(\frac{1}{1-\delta}\right)^{j-s+1} \cdot INV_{i,1992-s} \\
\overleftrightarrow{K}_{it} &= \begin{cases} \frac{1}{2}\left(\overleftarrow{K}_{i,t} + \overrightarrow{K}_{i,t}\right) & \text{if both } \overrightarrow{K}_{i,t} \text{ and } \overleftarrow{K}_{i,t} \text{ exist} \\ \max\left(\overleftarrow{K}_{i,t}, \overrightarrow{K}_{i,t}\right) & \text{otherwise.} \end{cases}
\end{aligned}
$$

B Estimating Plant Productivity

Throughout the paper, our productivity measures are derived from plant-level estimates of multi-factor productivity. We start with a model of a profit maximizing firm which faces the same input prices and market structure as other firms within the industry. In addition, production technologies are common to firms within the industry and across years. Individual firms may differ in terms of productive efficiency. Following Ericson and Pakes (1995) and Olley and Pakes (1996), each period the firm first decides to continue operation ($\chi = 1$) or shut down ($\chi = 0$) given its expectations about future productive efficiency and the current capital stock. If it continues, the firm faces choices of the level of variables inputs, such as labor and materials, and investment for future production given the existing capital stock and expectations about its productivity efficiency. Capital is accumulated according to

$$k_{t+1} = (1-d)k_t + i_t \tag{5}$$

Firm productivity consists of two components, $\omega_t + \epsilon_{it}$. ω_t is assumed to be known to the firm at date t (but unknown to the econometrician) and is first order Markov, while ϵ_{it} is unknown both to the firm and the econometrician. We will assume that the known productivity process is exogenous to the firm.

The exit rule for the firm is given by

$$\begin{aligned} \chi_t &= 1 \text{ if } \omega_t \geq \underline{\omega}\left(a_t, k_t\right) \\ & \quad 0 \text{ otherwise} \end{aligned} \tag{6}$$

so the firm remains in existence if productivity is above the threshold $\underline{\omega}$, conditional on the age of the firm, a_t, and the existing capital stock k_t.

Since investment is assumed not to be productive until the following period, the firm chooses investment in year t to obtain the optimal level of capital in year $t+1$. The investment decision can thus be written as

$$i_t = i\left(w_t, a_t, k_t\right) \tag{7}$$

We assume that the firm combines capital, two types of labor, and materials to produce a homogeneous product via a Cobb-Douglas production function. We allow for the possibility of increasing, decreasing or constant returns to scale, assume that productivity differences are Hicks neutral, and assume all firms within an industry face the same price. This latter assumption of identical prices is clearly wrong given the known heterogeneity of products produced within a single industry but is unavoidable given the limitations of the data.

The production function is given by

$$y_{it} = \beta_0 + \beta_a a_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it} \tag{8}$$

where y_{it} is the log of the value of real production from the firm, a_{it} is the age of the firm, k_{it} is the capital stock, l_{it} is the vector of labor inputs, m_{it} is the vector of purchased material inputs, ω_{it} is the productivity, and ϵ_{it} is any unforecastable shock, i.e. either to productivity or prices. We will implement the Olley-Pakes (1996) estimation procedure to address two distinct problems with OLS estimates of the production parameters. First, firms will increase their use of variable inputs, labor and materials, in response to a positive productivity shock that they can observe but is unknown to the econometrician, thus inducing a positive bias in the OLS coefficients on the variable inputs. Second, if plant profitability is positively related to the level of capital, then ceteris paribus firms with greater capital stocks will survive lower realizations of productivity, i.e. the expected future draw of productivity will be negatively related to the capital stock leading to a negative bias in the capital coefficient.

This requires the assumption that investment at date t is an increasing function of known productivity at date t, allowing us to write the known component of today's productivity as

$$\omega_t = h\left(i_t, a_t, k_t\right). \tag{9}$$

To address the two concerns about the production function parameter estimates, we first estimate the coefficients on the variable parameters with the semi-parametric estimator

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi_t\left(i_t, a_t, k_t\right) + \epsilon_{it} \tag{10}$$

where

$$\phi_t\left(i_t, a_t, k_t\right) = \beta_0 + \beta_a a_{it} + \beta_k k_{it} + h\left(i_t, a_t, k_t\right)$$

is a fourth order polynomial series estimator in investment, capital, and age.

The estimation in equation 7 does not yield consistent capital coefficients and we still face the problem of a potentially biased coefficient due to the shutdown decision. We estimate the shutdown decision in a probit with age, capital stock, and investment yielding a probability of shutdown, P_t, for each plant and year.

$$\Pr\left(\chi_{t+1} = 1\right) = \xi_t\left(i_t, a_t, k_t\right) = P_t \tag{11}$$

Finally we employ a nonlinear, semi-parametric series estimator to generate consistent coefficients on capital,

$$\begin{aligned} y_{it+1} - \widehat{\beta}_l l_{it+1} - \widehat{\beta}_m m_{it+1} &= \beta_0 + \beta_a a_{it+1} + \beta_k k_{it+1} \\ &\quad + g\left(P_t, \phi_t - \beta_a a_{it} - \beta_k k_{it}\right) + \omega_{it+1} + \epsilon_{it+1}. \end{aligned} \tag{12}$$

From which we can construct our desired measure of plant productive efficiency,

$$p_{it} = y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_m m_{it} - \widehat{\beta}_a a_{it} + \widehat{\beta}_k k_{it}. \tag{13}$$

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Table 1 : Exporters and TFP Growth[1]
(Dependent variable: annual plant TFP growth rates)

Export Dummy	-0.0021	-0.0020	-0.0056***	-0.0072***
	(0.0013)	(0.0013)	(0.0014)	(0.0015)
Year Dummies		X	X	X
Industry Dummies (2-digit)			X	
Industry Dummies (4-digit)				X

[1] Observations are weighted by their sampling probabilities in the ASM. All regressions were run with Huber-White corrections. *** indicates significance at the 1% level. ** indicates significance at the 5% level. * indicates significance at the 10% level. Plant controls include (log) total employment, average wage, and share of non-production workers in total employment.

Table 2 : Export Status and Productivity Growth[1]
(Dependent variable: annual plant TFP growth rates)

Export Status				
Stopper (1,0)	-0.0023	-0.0045*	-0.0075***	-0.0092***
	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Throughout (1,1)	0.0000	0.0004	-0.0030**	-0.0040**
	(0.0015)	(0.0015)	(0.0015)	(0.0016)
Starter (0,1)	0.0250***	0.0200***	0.0170***	0.0156***
	(0.0024)	(0.0024)	(0.0024)	(0.0024)
Year Dummies		X	X	X
Industry Dummies (2-digit)			X	
Industry Dummies (4-digit)				X

[1] Coefficients represent differences from growth rates at plants that did not export in either year, (0,0). Observations are weighted by the product of plant employment and the ASM sampling probabilities. All regressions were run with Huber-White corrections. *** indicates significance at the 1% level. ** indicates significance at the 5% level. * indicates significance at the 10% level. Plant controls include (log) total employment, average wage, and share of non-production workers in total employment.

Table 3: TFP Before, During and After Entry (or Exit)

	Export Type				
	Never	Stoppers	Other	Starters	Always
-2	0	0.055*$^{+}$ (0.011)	0.024*$^{+}$ (0.009)	0.029*$^{+}$ (0.011)	0.093* (0.008)
-1	-0.003 (0.006)	0.039*$^{+}$ (0.010)	0.031*$^{+}$ (0.008)	0.033*$^{+}$ (0.010)	0.099* (0.007)
0	0.001 (0.007)	0.027*$^{+}$ (0.009)	0.020*$^{+}$ (0.008)	0.040*$^{+}$ (0.009)	0.090* (0.008)
+1	0.001 (0.008)	0.014^{+} (0.011)	0.024*$^{+}$ (0.009)	0.060* (0.011)	0.085* (0.008)
+2	-0.002 (0.009)	-0.004^{+} (0.013)	0.024*$^{+}$ (0.011)	0.061* (0.013)	0.082* (0.010)

* indicates that the coefficient is significantly different from Never(-2) at the 5% level. $^{+}$ indicates that the coefficient is significantly different from Always(+2) at the 5% level.

Table 4 : Exporters and Plant Growth[1]
(Coefficients on exporter dummies in year ahead growth regessions)

Dependent Variable				
Employment Growth	0.0108***	0.0091***	0.0096***	0.0079***
	(0.0013)	(0.0013)	(0.0013)	(0.0014)
Total Shipments Growth	0.0132***	0.0113***	0.0079***	0.0057***
	(0.0015)	(0.0015)	(0.0016)	(0.0017)
Domestic Shipments Growth	0.0364***	0.0344***	0.0337***	0.0302***
	(0.0015)	(0.0015)	(0.0016)	(0.0023)
Additional Controls				
Year Dummies		X	X	X
Industry Effects (2-digit)			X	
Industry Effects (4-digit)				X

[1] All regressions were run with Huber-White corrections. *** indicates significance at the 1% level. ** indicates significance at the 5% level. * indicates significance at the 10% level.

Table 5: Employment Growth Rates Before, During and After Entry (or Exit)

	Export Type				
	Never	Stoppers	Other	Starters	Always
-2	0	0.0000+ (0.0106)	0.0097+ (0.0050)	0.0050+ (0.0106)	0.0271* (0.0052)
-1	-0.0055+ (0.0096)	-0.0083+ (0.0089)	0.0105 (0.0097)	0.0151 (0.0092)	0.0325* (0.0097)
0	-0.0111+ (0.0105)	-0.0081+ (0.0113)	0.0062 (0.0106)	0.0350* (0.0114)	0.0231* (0.0106)
+1	-0.0106+ (0.0122)	-0.0122+ (0.0125)	0.0120 (0.0123)	0.0383* (0.0126)	0.0370* (0.0122)
+2	0.0170 (0.0138)	-0.0033+ (0.0145)	0.0412* (0.0139)	0.0402* (0.0145)	0.0496* (0.0139)

* indicates that the coefficient is significantly different from Never(-2) at the 5% level. + indicates that the coefficient is significantly different from Always(+2) at the 5% level.

Table 6: Decomposition of Manufacturing TFP Growth by Plant Type
(all sectors)

	Reallocation Effect	Own-Productivity Effect	Overall
Export Status		*Growth Rates*	
Stopper (1,0)	-0.0041	-0.0003	-0.0044
Throughout (1,1)	0.0123	0.0055	0.0178
Starter (0,1)	0.0045	0.0014	0.0059
Neither (0,0)	-0.0067	0.0016	-0.0051
All	0.0059	0.0082	0.0142
		% of Total Growth Rate	
Stopper (1,0)	-28.9%	-1.8%	-30.7%
Throughout (1,1)	86.8%	38.7%	125.5%
Starter (0,1)	31.4%	10.0%	41.3%
Neither (0,0)	-47.3%	11.2%	-36.1%
All	41.9%	58.1%	100.0%

Table 7: Decomposition of Manufacturing TFP Growth (Industry Level)
(all industries)

	Reallocation Effect	Own-Productivity Effect	Overall
		Growth Rates	
All	0.0032	0.0110	0.0142
		% of Total Growth Rate	
All	22.5%	77.5%	100.0%

Table 8: The Contribution of Exports to Reallocation and TFP Growth

	Reallocation Effect		Own-Productivity Effect		Overall
	Domestic	Exports	Domestic	Exports	
Export Status	*Growth Rates*				
Stopper (1,0)	0.0049	-0.0090	-0.0001	-0.0001	-0.0044
Throughout (1,1)	0.0037	0.0086	0.0048	0.0007	0.0178
Starter (0,1)	-0.0066	0.0111	0.0013	0.0001	0.0059
Neither (0,0)	-0.0067	0.0000	0.0016	0.0000	-0.0051
All	-0.0048	0.0107	0.0076	0.0007	0.0142
	% of Total Growth Rate				
Stopper (1,0)	34.3%	-63.3%	-0.8%	-1.0%	-30.7%
Throughout (1,1)	26.0%	60.9%	33.8%	4.9%	125.6%
Starter (0,1)	-46.6%	77.9%	9.3%	0.7%	41.3%
Neither (0,0)	-47.4%	0.0%	11.2%	0.0%	-36.1%
All	-33.6%	75.5%	53.5%	4.6%	100.0%

Table 9: Shutting Down the Export Sector - A Counterfactual

	Reallocation Effect	Own-Productivity Effect	Overall
Export Status	*Growth Rates*		
Stopper (1,0)	0.0057	-0.0001	0.0056
Throughout (1,1)	0.0092	0.0051	0.0143
Starter (0,1)	-0.0064	0.0014	-0.0050
Neither (0,0)	-0.0035	0.0017	-0.0018
All	0.0050 (84.7%)	0.0081 (98.7%)	0.0131 (92.2%)
	% of Total Growth Rate		
Stopper (1,0)	43.4%	-1.0%	42.5%
Throughout (1,1)	70.3%	38.8%	109.1%
Starter (0,1)	-48.7%	10.8%	-37.9%
Neither (0,0)	-26.7%	13.0%	-13.7%
All	38.4%	61.6%	100.0%

This table contains a decomposition of productivity under the assumptions that there were no exports during the period and plant TFP and domestic shipments trajectories remain unchanged. Numbers in parentheses represent the ratio of the non-export growth component to the observed growth component with exports.

Table 10: Exporting and Importing Industries

Industry Type	Reallocation Effect	Own-Productivity Effect	Overall
	Growth Rates		
Trade Intensive	0.0068	0.0006	0.0074
Export Intensive	0.0082	0.0035	0.0117
Import Intensive	-0.0006	0.0015	0.0010
Non-Tradable	-0.0039	-0.0001	-0.0040
Other	-0.0046	0.0027	-0.0019
All	0.0059	0.0082	0.0142
	% of Total Growth Rate		
Trade Intensive	47.9%	4.6%	52.5%
Export Intensive	58.1%	24.7%	82.8%
Import Intensive	-3.9%	10.8%	6.8%
Non-Tradable	-27.8%	-0.7%	-28.6%
Other	-32.5%	18.9%	-13.6%
All	41.8%	58.2%	100.0%

Table 11: Exporters and Industry Types

Industry Type	Plant Type	Reallocation	Own	Total
Trade Intensive	Stopper (1,0)	2.5%	0.6%	3.1%
	Throughout (1,1)	28.5%	0.4%	28.9%
	Starter (0,1)	6.9%	1.6%	8.5%
	Neither (0,0)	9.9%	1.9%	11.8%
Export Intensive	Stopper (1,0)	-8.2%	-2.3%	-10.5%
	Throughout (1,1)	58.9%	22.8%	81.7%
	Starter (0,1)	4.7%	1.6%	6.4%
	Neither (0,0)	2.5%	2.4%	5.0%
Import Intensive	Stopper (1,0)	-7.6%	1.0%	-6.6%
	Throughout (1,1)	0.3%	4.7%	4.9%
	Starter (0,1)	10.5%	1.7%	12.2%
	Neither (0,0)	-7.1%	3.4%	-3.7%
Non-Tradable	Stopper (1,0)	-1.7%	-0.5%	-2.2%
	Throughout (1,1)	0.1%	0.5%	0.6%
	Starter (0,1)	1.2%	0.7%	1.9%
	Neither (0,0)	-27.4%	-1.5%	-28.8%
Other	Stopper (1,0)	-14.0%	-0.6%	-14.6%
	Throughout (1,1)	-0.9%	10.2%	9.4%
	Starter (0,1)	8.1%	4.3%	12.4%
	Neither (0,0)	-25.3%	4.9%	-20.4%